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Dysfunction of the Gluteus Maximus and Medius in Achilles Tendinopathy

Self-study material for SAMK students

DEGREE PROGRAMME IN PHYSIOTHERAPY
2023

Author(s) Bobet, Julien	Type of Publication Bachelor's thesis	3.10.2023
	Number of pages 31	Language of publication: English
Title of publication: Dysfunction of Gluteus Maximus and Medius in Achilles Tendinopathy: Self-learning material for SAMK students		
Degree Programme: Physiotherapy		

Abstract

Achilles Tendinopathy (AT) is one the most common lower limb injury among athletes and active people. Its rehabilitation is mainly focused locally. The holistic approach of physiotherapy opens opportunities to focus AT's rehabilitation proximally. Research already proved to correlation between hip and knee and hip and ankle. The author wanted to extend this correlation to AT and study the types of dysfunctions that can occur at the hip.

The work studied the connection between gluteus Maximus and Medius dysfunctions and Achilles tendinopathy. The dysfunctions mentioned are strength and neuromuscular control affecting the biomechanics of hip and ankle.

The aim was to increase the knowledge of physiotherapy students and bring another perspective on AT rehabilitation. The aim was achieved by sharing the information through a self-learning material available on the platform Moodle. The independent learning material explained the basis of Achilles Tendinopathy, hip and ankle biomechanics and how dysfunctions of gluteus Maximus and Medius impact distal biomechanics.

The author found a great connection between AT and hip muscles dysfunction, especially in the loss of neuromuscular control and isometric strength impacting the biomechanics of the ankle.

The self-learning material, created with H5P program, were meant to physiotherapy students.

The author encountered a small amount of research studying the topic. More studies need to be done to broaden AT rehabilitation and prevention in a holistic approach.

Keywords
Achilles Tendinopathy, hip biomechanics, ankle biomechanics, gluteus medius, gluteus maximus, dysfunctions, isometric strength, neuromuscular

CONTENT

LIST OF SYMBOLS AND TERMS (NOT COMPULSORY)

At	Achilles Tendon
AT	Achilles Tendinopathy
IAT	Insertional Achilles Tendinopathy
NIAT	Non-Insertional Achilles Tendinopathy
NC	Neuromuscular Control
IS	Isometric Strength
SEBT	Star Excursion Balance Test
TS	Triceps Surae
GMAX	Gluteus Maximus
GMED	Gluteus Medius

1 INTRODUCTION

In 2013 and 2016, the magazine Runner's World wrote two articles called "Achilles Pain, Poor Glute Control Linked" (Douglas, 2016) and "if you have Achilles pain, look to your hips" (Douglas, 2013) and enlightens research from Australian biomechanists. They found an abnormal movement pattern in runners with Achilles Tendinopathy as well as a poor recruitment, in time and strength, of gluteal muscles. Furthermore, the same year, Peter Malliaras reports a notion addressed by Habets et al., (2017) , on a blog post on his website Tendinopathy Rehabilitation, the notion of kinetic chain in Achilles tendinopathy. Another research conducted by Franettovich Smith et al., (2014), revealed that hip biomechanics alteration impacts the ankle biomechanics and mentioned that neuromuscular control differences in gluteal muscles can impact hip and ankle biomechanics. Finally, McCann et al., (2018) enlightened the association with hip isometric strength and chronic ankle instability. A direct link between hip joint and ankle joint was found and needed more attention.

The focus of this thesis is on the dysfunction of gluteus Medius (Gmed) and Gluteus Maximus (Gmax) in people suffering of Achilles Tendinopathy. This thesis reviews the biomechanical changes in ankle due to hip dysfunction, the loss of muscle strength and stability. This thesis also offers element of answers worth mentioning regarding Achilles tendinopathy rehabilitation such as hip control tests, isometric hip strength measurement and neuromuscular control rehabilitation.

The author encountered research about the connection between hip dysfunctions and knee injuries as well as hip dysfunctions and chronic ankle instability. It is the reason why the author wanted to extend the connection to Achilles Tendinopathy.

1.1 Definition of the topic

The author wants to study the association of the dysfunction of the gluteal muscles, specifically Gluteus Medius (Gmed) and Gluteus Maximus (Gmax), and Achilles tendinopathy (AT).

1.2 Expected results

The author expects to gain a better understanding of this complex musculoskeletal issue as well as a better knowledge about concepts developed in the thesis such as biomechanics, neuromuscular control, strength, and stability. The author expects to comprehend how neuromuscular control and strength rehabilitation in Gluteus Maximus and Medius impact the rehabilitation of AT. Furthermore, the author expects to introduce an additional tool to the rehabilitation of Achilles tendinopathy to physiotherapy students through the self-study material, via the platform H5P. The author wants to provide a wider view and reflection on the specific AT issue and its possibility in its rehabilitation.

In addition, the author knows that, after some readings, that a clear link and association between hip joint dysfunctions and AT is not obvious yet. Literature does not stipulate neither disprove a causality between these two issues.

2 AIM AND OBJECTIVES

The aim of this thesis is to increase evidence-based knowledge regarding Achilles Tendinopathy itself and the association of gluteal muscles dysfunctions in people with Achilles tendinopathy. The thesis will focus on neuromuscular deficiency, isometric strength weakness as well as the biomechanical impacts. The work will be supported by evidence-based information. The thesis is targeting SAMK physiotherapy students through the creation of a self-study material on the learning platform Moodle.

3 ACHILLES TENDINOPATHY

3.1 Definition and classification of tendon disorders

This part will discuss the definition of AT and its classification.

3.1.1 Definition

Achilles tendinopathy (AT) is a term that has been commonly used since 1998, brought by Malfulli et al. due to the lack of inflammatory reaction in the tendon (Li & Hua, 2016). In 2019, a symposium about Achilles issues was held in the Netherlands to define the right terminology and concluded with Achilles Tendinopathy, a term that underlines tendon's soreness and capacities as well as helps build treatment and improve therapists and patients' education (Scott et al., 2020). Furthermore, the increase of pain, the decrease of performances and swelling is part of the clinical diagnosis (Longo et al., 2009; Maffulli et al., 2020; Silbernagel et al., 2020). AT occurs in people performing sports with repetitive movements, for example running or jumping (Aicale et al., 2020). The mechanism of Achilles tendon injury is first and foremost connected to an increase in loading, compared to the capacity of the tendon (Silbernagel et al., 2020b).

3.1.2 Classification

Practicians, experts, and researchers differentiate two main types of AT: insertional AT (IAT) and non-insertional AT (NIAT) (or mid-portion AT). IAT is usually diagnosed through manual evaluation and interviews of patients. (Chimenti et al., 2017).

Furthermore, IAT is caused by a bone creation and tendon calcification around the attachment (Zhi et al., 2021).

Mid-portion AT is a regular disorder that comes with soreness and rigidity 2 to 6 cm over the insertion (Rabusin et al., 2021).

3.2 Clinical symptoms

In insertional AT, manual examination reveals pain at the attachment level of the tendon (Zhi et al., 2021) It is characteristic to notice softness when palpating around 2cm above the insertion (Chimenti et al., 2017). It is also visible on the calcaneus where practicians can notice a bulge and redness (Chimenti et al., 2017).

Regarding non-insertional AT, manual examinations reveal a thicker tendon and pain (Pearce & Tan, 2016).

3.3 Assessment of a tendon

In 2020, Silbernagel et al., presented the current assessment of a NIAT and IAT. The authors reported that pain during manual examination two to six centimeters over the attachment is a good indicator of NIAT (figure 1, Silbernagel et al., 2020b). Furthermore, the pain area is crucial to differentiate IAT and NIAT (Figure 1, Silbernagel et al., 2020b).

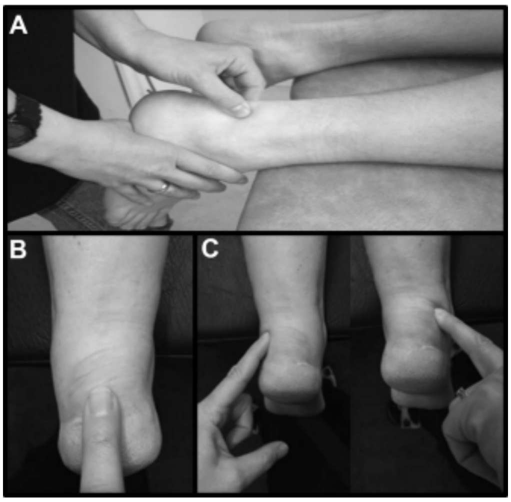

Figure 1. Pain location of IAT and NIAT (Silbernagel et al., 2020b)

For deeper analysis, De Vos et al. (2021), in the Dutch Multidisciplinary Guideline on Achilles Tendinopathy, stipulates four different outcomes for IAT and NIAT. These are presented below in figure 2:

Diagnose midportion Achilles tendinopathy based on the presence of all the following findings:
1. Symptoms localised 2–7 cm proximal to the Achilles tendon insertion.
2. Painful Achilles tendon midportion on (sports) loading.
3. Local thickening of the Achilles tendon midportion (this may be absent in cases with short symptom duration).
4. Pain on local palpation of the Achilles tendon midportion.

Diagnose insertional Achilles tendinopathy based on the presence of all the following findings:
1. Symptoms localised to the Achilles tendon insertional region (within 2 cm of the insertion of the Achilles tendon).
2. Painful Achilles tendon insertional region on (sports) loading.
3. Local thickening of the Achilles tendon insertion (this may be absent in cases with short symptom duration).
4. Pain on local palpation of the Achilles tendon insertion.

No additional imaging studies are needed if the presenting case fits all four diagnostic criteria.

Figure 2. Guidelines of diagnoses of IAT and IAT (Silbernagel et al., 2020b)

Also, the authors specified these assessments are reliable and that no supplementary imagery are necessary (De Vos et al., 2021).

3.4 Pathology of Achilles Tendinopathy: The continuum Model

Cook and Purdam introduced the Continuum Model in 2009 in response of lack of constant pathological explanations, centered on load control (Cook & Purdam, 2009). The goals were to explain the different aptitude of a tendon to improve, to debate about the limitations for a tendon to function without pain, and finally to offer stage-made solutions (Cook & Purdam, 2016).

The continuum model describes three different steps and stipulates that tendon can to go back and forth within the stages (Cook & Purdam, 2009). The three stages of the continuum model are explained below:

Reactive tendinopathy is a reaction to an increase in load, with no inflammation as well as an increase of tendon's size (Cook & Purdam, 2009; Li & Hua, 2016; Mccreesh & Lewis, 2013). The response to load is a modification in cell shape and a multiplication of cells in the tendon that will increase the secretion of protein and leads to a matrix modification. The integrity of the collagen fibers is intact (Cook & Purdam, 2009).

Tendon Dysrepair is the attack at the restorative process (Cook & Purdam, 2009). The main characteristic of this stage is the split of collagen, disturbance of the matrix and possibility of multiplication of vascularisation and neuronal development (Cook & Purdam, 2009; Mccreesh & Lewis, 2013).

Degenerative tendinopathy is best described through the loss of cell (Cook & Purdam, 2009). Tendon abilities to revert changes are limited (Cook & Purdam, 2009).

3.5 Pathophysiology

A healthy tendon had a matrix ideally hydrated and made of category one collagen fibers (Scott et al., 2015). The right balance in Achilles tendon is controlled by the load and cell actions (Ackermann et al., 2018). An issue in these regulations causes tendinopathy (Ackermann et al., 2018). Exercising enhances the anabolic process in Achilles tendons by producing collagen gene and protein 24h post activity (Ackermann et al., 2018). It also triggers a catabolic process, by decreasing proteins, 24-36 hours post exercises (Ackermann et al., 2018). The main factor in AT, is a separation of collagen fibers leading to a change of composition, through an increase of category III collagen, vascularisation, neuronal connection, and hydration (Ackermann et al., 2018; Scott et al., 2015).

3.6 Risk factors

The temporality of the disease plays a central role to point risk factors. In the acute phase, extrinsic influences seem to lead such as the way people are training, their shoes and where they do physical activity (Aicale et al., 2020).
On the chronic phase of the disease, intrinsic factors, like aging, triceps Surea issues, ankle unsteadiness among others, also play a major role (Aicale et al., 2020).

4 REVIEW OF ACHILLES TENDON AND GLUTEAL MUSCLES

4.1 Achilles tendon

Achilles tendon (At), or Calcaneal tendon, is defined as the sturdiest tendon (O'Brien, 2005). The At is the most exposed to overuse injuries due to its exposure to high load (O'Brien, 2005).

4.1.1 Anatomy of triceps Surae and Achilles tendon

The muscles contributing to Achille tendon are, from the most posterior to the most anterior: Gastrocnemius and Soleus. The two gastrocnemius heads, medialis and lateralis, and Soleus muscles form the triceps Surae (TS) (Bell et al., 2022).

Gastrocnemius is the most apparent muscle from the TS that gives the shape of the calf muscle, crosses the knee joint through the popliteal fossa (O'Brien, 2005). It is composed of two heads, medial and lateral that connect in the middle line on the posterior area of the muscle (Winnicki et al., 2020). Gastrocnemius has a mix of muscle fibers, but mainly constituted of fast twitch ones, made for explosivity and power (Fields & Rigby, 2016).

The Soleus appears bigger and larger compared to gastrocnemius (O'Brien, 2005). Soleus and Gastrocnemius have similar roles, but their muscle fibers differ (Winnicki et al., 2020). Soleus is mainly made of slow twitch fibers, made for stamina activities (Fields & Rigby, 2016).

The gastrocnemius' lateral and medial parts' origin is both condyles of the femur, respectively (Winnicki et al., 2020). Gastrocnemius tendon unifies with Soleus muscle to create Achilles tendon (O'Brien, 2005). The origin of the soleus muscle is the proximal fibula and the soleal line (Winnicki et al., 2020). The Gastrocnemius and the Soleus are responsible for plantar flexion (Dederer & Tennant, 2019). The soleus works as a vascular pump (Dederer & Tennant, 2019). Due to its insertion, the Gastrocnemius flexes the knee (Dederer & Tennant, 2019).

Being the longest tendon of the human body, At measures 15 cm (O'Brien, 2005). The specificity of At has increased significantly since 2013 to define disorders (Winnicki et al., 2020). It starts from the insertion on the calcaneus which continues to the pre-insertion, approximately 2 cm over the insertion (Winnicki et al., 2020). A fat pad protects the calcaneal insertion (Winnicki et al., 2020). The area called mid-portion is in between the calcaneal insertion and calf muscle insertion (Winnicki et al., 2020). The insertion of At is energy storing (Dederer & Tennant, 2019). Achilles tendon is not simply attached to the calcaneal bone but it twists, 90° angle laterally, down to the insertion (Dederer & Tennant, 2019). Nevertheless, At does not have a uniformed insertion as the left and right side curl in different direction (Dederer & Tennant, 2019).

4.1.2 Physiology: vascular supply and innervation

In 2017, Dayton said that blood supply in the tricep surea comes from muscle-tendon and tendon-bone intersection (Dayton, 2017). The vascular supply to At is provided by different arteries. On the medial side, the posterior tibial artery crosses the leg (Winnicki et al., 2020). Laterally, the peroneal artery provides the tendon in blood (Winnicki et al., 2020). Superior and inferior sides of the tendon are vascularised by the posterior tibial artery whereas mid-tendon is vascularised through peroneal artery (Winnicki et al., 2020). Furthermore, the different section of At is not equally provided in blood as the frontal part of the tendon received better blood supply than the posterior one (Winnicki et al., 2020). Also, most of the blood supply comes from little vessels in the paratenon (Dederer & Tennant, 2019). The paratenon is the tendon's most outside level (Müller et al., 2018). The nerve activating At is the sural nerve, which also contributes to sensory information (Wong et al., 2022). Tibial nerve's small branch is also implicated in minor activation (Wong et al., 2022).

4.2 Gluteal Maximus and Gluteus Medius

This paragraph will review the anatomy and function of Gluteus Medius (Gmed) and Gluteus Maximus (Gmax).

4.2.1 Anatomy

Gluteus maximus (GMax) is considered as the largest gluteal muscles (Tortora & Derrickson, 2017). It originates from the crest of the iliac bone, the coccyx, the gluteal surface of the iliac bone and insert to iliotibial band as well as the gluteal tuberosity of the femur (figure 3) (Grujičić, 2022). GMax is innervated by inferior gluteal nerve that originates from L5-S2 (Grujičić, 2022). The blood supply of GMax comes from the muscle branches of inferior and superior gluteal arteries (Grujičić, 2022).

Figure 3- Gluteus Maximus (Grujičić, 2022)

Gluteus Medius (GMed) originates from the gluteal surface of the iliac bone and inserts to the femur on the greater trochanter (figure 4) (Grujičić, 2022; Tortora & Derrickson, 2017). Unlike GMax, Gmed is inverted by the superior gluteal nerve that originates from L4-S1 (Grujičić, 2022). GMed is vascularized through the deep branch of superior gluteal artery (Grujičić, 2022).

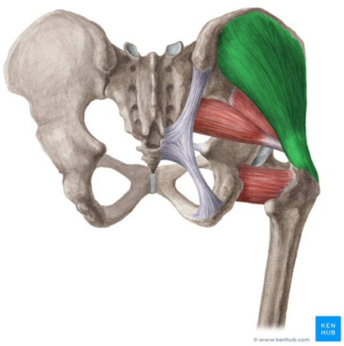

Figure 4. Gluteus Medius (Grujičić, 2022)

4.2.2 Functions

GMax plays a major role in the extension of the femur as well as laterally rotating the thigh that happens at the same moment of the extension (Grujičić, 2022; Tortora &

Derrickson, 2017). Furthermore, Gmax's superior muscle fibers are active in the abduction movement while the inferior muscles fibers participate in the adduction movement (Grujičić, 2022). Another important function of GMax is the stability of the knee from its lateral side, by tensing the fascia lata through its more distal attachment (Grujičić, 2022).

GMed is known for its contribution to hip stabilization, through the pulling action applied to the head of the femur and the abduction movement (Grujičić, 2022). GMed is also involved in the internal rotation of the hip (Grujičić, 2022; Tortora & Derrickson, 2017).

5 HIP GAIT CYCLE AND BIOMECHANICS

5.1 Gait analysis: Hip focus

The figure 5 below presents the common steps during gait cycle.

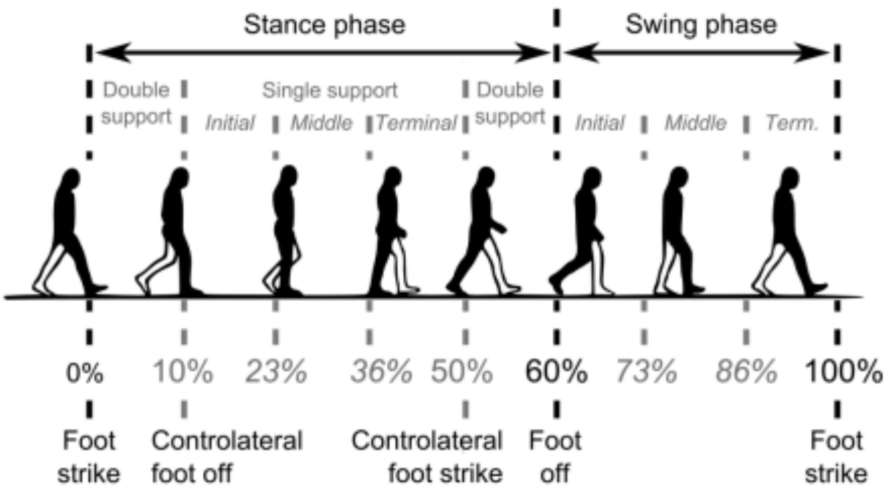

Figure 5. Common temporal division of the gait cycle (Bonnefroy-Mazure & Armand, 2015)

In sagittal plane, the hip joint rotates by 40° (Krebs et al., 1998). In the frontal plane, adduction of the hip happens in early stance phase, whereas the hip abducts by 5-7°in early swing (Krebs et al., 1998). The maximum extension of the hip happens at the heel-off stage of the gait cycle whereas the hip is maximally flexed during the end of the swing phase (Polkowski & Clohisy, 2010). The hip joint is maximally intenally rotated at mid-stance, and adducted during the stance phase whereas the swing forward motion triggers abduction and external rotation (Krebs et al., 1998; Polkowski & Clohisy, 2010). During the swing phase, the hip joint is externally rotated (Krebs et al., 1998; Polkowski & Clohisy, 2010). It is important to notify that a smooth control in gait is due to a well-functioning eccentric and concentric muscular contraction (Bowman et al., 2010)

The figure 6 presented by Polowski and Clohisy (2010) below describes the different positions of the hip during the height phases of the gait cycle as well as muscles involved during different motion of gait.

TABLE 2. Eight Phases of the Gait Cycle[30]

Phase of Gait	Hip Position	Active Muscles	Occurrence During Cycle (%)
Stance			
Initial contact	30 degrees of flexion	Hamstrings and gluteus maximus	0-2
Loading response	30 degrees of flexion 5 to 10 degrees of adduction 5 to 10 degrees internal rotation	Hamstrings and gluteus maximus	0-10
Mid-stance	0 degrees of flexion-extension Neutral abduction-adduction	Gluteus medius, gluteus minimus, and tensor fascia lata	10-30
Terminal stance	10 degrees of extension	Iliacus	30-50
Pre-swing	0 degrees of flexion-extension	Iliacus and adductor longus	50-60
Swing			
Initial swing	20 degrees of flexion 5 degrees of abduction	iliopsoas, rectus femoris, gracilis, and sartorius	60-73
Midswing	20 to 30 degrees of flexion	iliopsoas, gracilis, and sartorius	73-87
Terminal swing	30 degrees of flexion	Hamstrings and gluteus maximus	87-100

Figure 6 – Eight phases of the Gait cycle (Polkowski & Clohisy, 2010)

On a neuromuscular level, a complex process maintains the good position of the head of the femur and the acetabulum trough muscular balance on both voluntary and unvoluntary level (Bowman et al., 2010). Furthermore, the hip joint is under constant load during daily activities (Bowman et al., 2010). It has been shown that a compressive force is constantly applied and can reach 3 times bodyweight during slow walking after heel strike, up to 4 times just before toe-off (Bowman et al., 2010; Polkowski & Clohisy, 2010). As the speed in walking increases, the load at the hip increases as well up to 7 to 8 times in running (Polkowski & Clohisy, 2010).

5.2 Gluteus Maximus and Medius actions in gait

Krebs et al. (1998) found that Gmed triggers an abduction movement to stabilize the pelvic height during a prolonged single-leg phase of the gait cycle. Gmed is considered as the hip abductor during gait, and its action is crucial in independent gait and balance (Lee et al., 2014).

Gmax muscle's contribution to gait is major and its dysfunction affects the gait cycle (Ferris, 2005). During the whole cycle of gait, but specifically during the stance phase, a force coming from the contact of the lower extremity with the ground, called Ground Reaction Force (GRF) is applied in response (Hall S.J, 2012). Gmax offers support to the leg through the GRF during early stance phase (Ferris, 2005). Gmax activity has also an impact on the distal part of the leg by initiating the rotation of the foot and the ankle rocker, where we notice the tibia advancing when the ankle initiates dorsiflexion, from the flat foot position to right before the heel off phase (Canavese, 2015; Ferris, 2005). Briefly, the ankle function during stance phase of the gait is to deliver a rolling motion described as three rockers, heel rocker, ankle rocker and forefoot rocker (Canavese, 2015, illustration in appendix). On knee and hip level, Gmax plays a role of antagonist muscle and controls the extension of the knee joint and participates to hip extension as well as control the rate of hip joint flexion and its duration (Ferris, 2005). Furthermore, Gmax muscle activity increases with faster walking speed (Lee et al., 2014).

6 HIP DYSFUNCTIONS IN ACHILLES TENDINOPATHY

6.1 Dysfunction of hip neuromuscular control

Here will be discussed and studied the neuromuscular control issues in Gmed and Gmax and their impact on gait biomechanics.

6.1.1 Gluteus Medius Dysfunction

In normal gait, it is known that Gmed activates before heel strike and during early stance to maintain the pelvic and to stabilize the hip (Franettovich Smith et al., 2014). In people with AT, it has been demonstrated that Gmed has a delayed onset in activation (or start of muscle contraction) before heel strike and an altered activation, translated as a shorter duration of activation (Franettovich Smith et al., 2014).

6.1.2 Gluteus Maximus Dysfunction

Likely, Gmax shows a delay in onset activation and a shorter duration of activation in people with AT (Franettovich Smith et al., 2014). Furthermore, Gmax exhibits an earlier offset (or end of contraction) (Franettovich Smith et al., 2014). These three dysfunctions trigger difficulties in controlling the position of the femur before heel strike and during the stance phase (Franettovich Smith et al., 2014).

6.2 Biomechanical changes in hip and ankle

Gmax is the main hip extensor and its dysfunction result in a loss of power of propulsion (Franettovich Smith et al., 2014). The hip and ankle joints work together to maintain propulsion motion, so a dysfunction in Gmax activation results in a greater contribution at the ankle joint (Franettovich Smith et al., 2014). This increase at the ankle joint provokes a need for stronger activation of the TS, hence, a heavier concentric load on the At (Franettovich Smith et al., 2014). The kinetic chain theory explains the relationship between hip adduction, internal rotation and rearfoot eversion (Franettovich Smith et al., 2014). This association is challenged by hip dysfunctions, as a lower activation of Gmed and Gmax will increase hip adduction and internal rotation excursion at the hip joint, hence, an increased rearfoot eversion (connected with AT) (Franettovich Smith et al., 2014).

6.3 Decreased of hip isometric strength

A systematic review conducted by Quarmby et al. in 2023 enlightened multiple studies that demonstrated the loss of 28.3%-34.2% of isometric strength in hip extensors**.** Furthermore, it has been showed that a loss of isometric strength in hip muscles is linked with a greater risk to cause distal lower limb injuries, due to a decreased ability to place lower limbs in a safe position during active movements (McCann et al., 2018). Different distal lower limb injuries and impairments (chronic ankle instability and lateral ankle sprains) have been linked with a decreased isometric strength at the posterolateral hip muscles together with a reduced dynamic control (McCann et al., 2018).

7 PHYSIOTHERAPY FOR GLUTEUS MUSCLES DYSFUNCTION IN ACHILLES TENDINOPATHY REHABILITATION

7.1 Gluteus Medius and Maximus isometric strength assessment

Trendelemburg test has usually been used to show Gmed isometric strength weakness, it is nowadays considered as an outdated test and not reliable. The Gmed isometric strength measures the hip abduction in supine or side lying. Physiotherapists can either manually assess the Gmed isometric strength, by applying pressure on lateral side of the knee or with the help of a handled dynamometer. When testing both sides, a difference of 10%, minimum, should be observed. (Stastny et al., 2016).

Gmax, although being the most powerful muscle of the body, it is prone to inhibition and weaknesses (Buckthorpe et al., 2019). To assess Gmax isometric strength, the patient must be in prone position. The tested hip is slightly laterally rotated, and the knee is bent at 90°. The dynamometer is put on the hamstrings, on the distal third part. (Aurélio et al., 2018).

7.2 Dynamic postural balance test: Star Excursion Balance Test

Star Excursion Balance Test (SEBT) is a dynamic test for postural control assessment for physically active people (Gribble et al., 2012). Standing in a single-leg squat position in the middle of a star shaped setup, participants will use the non-stance leg to reach and touch different point positioned on the ground (Gribble et al., 2012) (figure 7 and 8).

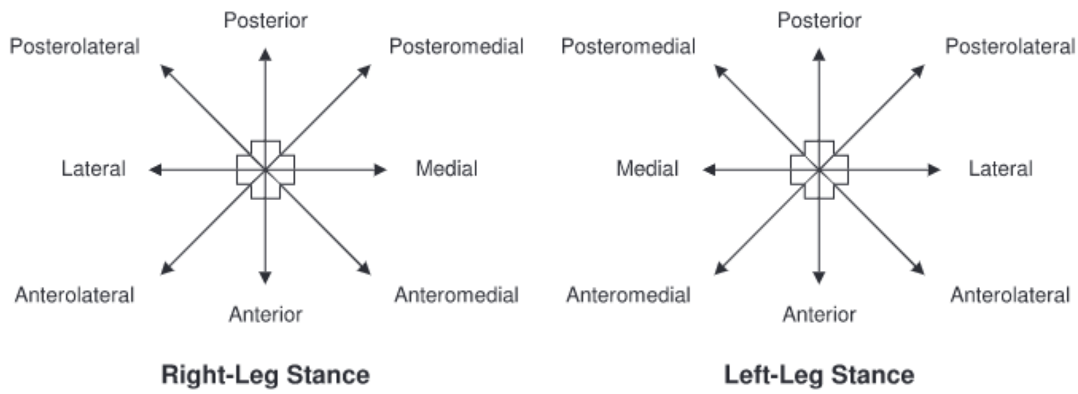

Figure 7. Reaching direction for the Star Excursion Balance test (Gribble et al., 2012)

Figure 8 – Performance of the Star Excursion Balance Test (Gribble et al., 2012)

The test measure how far the participant can reach staying stable (Gribble et al., 2012). This test assesses differences between injured and non-injured legs as well as deficits or improvements in dynamic postural control (Gribble et al., 2012). Another interesting aspect of the test is to assess movement pattern, or the ability of participants to maximally reach a point (Gribble et al., 2012). Researchers found out that knee flexion and hip flexion contribute largely to the performance of the test and might explain the difficulties of performing it for participants with lower limb injuries, most likely because of the muscle groups involved in the stability of these joint during dynamic tasks (Gribble et al., 2012). Another study conducted by Bhanot et al. (2020) helped to understand that during SEBT, muscle activation is direction dependent (Bhanot et al., 2020). More specifically, the authors discovered that Gmax greatest activity was in the posterior direction to control the hip flexion and avoid loss of balance, whereas the highest activation of Gmed was observed in medial direction to prevent the drop of the pelvis (Bhanot et al., 2020) Furthermore, it has been specified that neuromuscular characteristics, like balance and strength, are needed for performing SEBT (Filipa et al., 2010). To conclude, the Star Excusion Balance Test is a complete test that shows reliable results and validity in predicting risk of lower limb injury (Gribble et al., 2012).

7.3 Neuromuscular rehabilitation

In 2010, Filipa et al. enlightened the support from studies to include neuromuscular training program to decrease the risk of lower injury. This statement is reinforced in 2017 by a study about trunk and hip-focused neuromuscular training-based program, called Targeted Neuromuscular Training (TNMT), for cruciate ligament injury risk, that was conducted by Hewett et al. (2017), to understand the effect and improvement for proximal control of the knee joint (Hewett et al., 2017). The results of this study showed changes in hip and knee for people exposed to a higher risk of injury (Hewett et al., 2017). Neuromuscular training improves the reach in posterolateral and posteromedial direction (Filipa et al., 2010). Also, it was stipulated that improvements in the above-mentioned directions are the results of a better neuromuscular control instead of lower extremity strength (Filipa et al., 2010). Biomechanically, neuromuscular training improves the external rotation moment at the hip joint (Hewett et al., 2017). Furthermore, including a neuromuscular control helps regain a hip-knee-ankle alignment (Hewett et al., 2017).

As an example, TNMT can include exercises reported in figure 7 below (Hewett et al., 2017):

TABLE 1
TNMT Exercise Progression[a]

Exercise	Published Studies
Lateral jump	Hewett et al,[5] Mandelbaum et al[10]
Hop-hold	Hewett et al[5]
BOSU single-knee hold	Myer et al[16]
Single-leg lateral Airex hop-hold	Myklebust et al,[21] Petersen et al[23]
Tuck jump	Hewett et al[5]
Lunge jump	Hewett et al[5]
Walking lunge	Mandelbaum et al[10]
BOSU single-leg pelvic bridge	Mandelbaum et al[10]
Table lateral crunch	Myer et al[16]
Table double crunch	Myklebust et al,[21] Petersen et al[23]
Back hyperextension with ball reach	Myer et al[16]
Single-leg 90° hop-hold	Myklebust et al,[21] Petersen et al[23]

[a]The full targeted neuromuscular training (TNMT) and control intervention plans are outlined in detail in the cited references.

Figure 9. Targeted Neuromuscular Training (Hewett et al., 2017)

7.4 Strength rehabilitation

A study conducted by Willy & Davis, (2011) demonstrated the impact of hip strength training. They focused their research on hip abduction and external rotation, recruited twenty female runners with excessive hip adduction and built a 6-weeks program training, three sessions per week (Willy & Davis, 2011). The authors found out that the external rotation strength increased by 40% (Willy & Davis, 2011). In 2017, Neelapala et al. (2017), in a study about chronic ankle instability and hip strength, demonstrated the positive relationship between Gmed and Gmax's isometric strength and good balance during the SEBT test. They enlightened the positive connection in anterior direction and gluteus muscles strength as well as the connection with Gmed strength in posteromedial and posterolateral direction (Neelapala et al., 2017). Gmax has a fair connection for good balance (Neelapala et al., 2017). In 2018, Camargo Saad et al., found a connection between hip strengthening program and patellofemoral pain in females. After 8 weeks of intervention, with two session per week, the authors discovered improvements in internal, external rotators and extensors of the hip (Camargo Saad et al., 2018).

8 METHOD AND THESIS PROCESS

The author used an action research approach by creating a self-learning material for SAMK students available on the Moodle Platform. The idea of the thesis was built from two practical placements where lower limb injuries were studied and from the author's personal interest in Achilles Tendinopathy. During his first placement in France, the author covered Achilles tendon rehabilitation. The second placement in Helsinki, offered to the author a holistic approach to lower limb injuries treatment. To create a self-learning material was a desire that came from the author's own experience to gain addition and deeper knowledge.

8.1 Schedule

Table 1: Schedule of the process

Starting the process	May-Jun 2022
Choosing topic	May-Jun 2022
Defining the topic	Oct-Nov 2022
Thesis plan presentation	15 Dec 2022
Writing process: Anatomy tendon/hip muscles Function tendon/hip muscles Achilles Tendinopathy (class., assess, symptoms) Biomechanics tendon/hip muscles Achilles Tendinopathy (pathophysiology)	 Dec 2022 Dec 2022 Dec 2022-Jan 2023 Dec 2022-Jan 2023 Jan 2023
Research question	Beg. Feb 2023
Preparing learning material	June-july 2023
Sending and piloting material	July-august 2023
Finalizing	Summer 2023
Presenting	Sept-Oct 2023

8.2 Evidence based knowledge

Each information found in the thesis comes from an evidence-based approach. Articles were found through search engines such as Google scholar, PubMed and Finna. The author used keywords such as “Achilles Tendinopathy”, “Gluteus Medius”, Gluteus Maximus”, “Hip and lower limb injuries”, “biomechanics”. The author also chose different combination to find more suitable sources.

Inclusion criteria were articles addressing biomechanical issues in hip, gluteal muscles dysfunctions and articles discussing the connection between hip and ankle to support my research. Exclusion criteria were non-English articles to avoid loss in translation and or risk of plagiarism.

8.3 Practical part: Self-learning material via the program H5P

At the beginning of the process, the author hesitated between giving a short lecture during Musculoskeletal class and creating a self-learning material for student. The author made the decision when he realized that a self-learning material on the platform Moodle, would also be useful for future physiotherapy students.

The material was created through the program H5P, displayed on the online platform Moodle. The author created an interactive book, where student can find information through texts and images. After each part, a quiz, made of multiple choice and true and false questions, was offered to ensure the understanding of information, and make a participating content. The self-learning material was thought to take maximum 60 minutes of students’ time.

8.4 Piloting

The author wanted the NPH21SP, NPH22SP and NPH22SP students to participate to the improvement of the H5P document. The author thought it was a logical choice due to students’ background in basic anatomy, musculoskeletal injuries, and practical placements. The author sent an email on the 22nd of September 2023 explaining the reasons why contacting them and presenting the thesis topic as well as the self-learning material. 6 volunteers were recruited to access the H5P interactive book and give feedback through a questionnaire.

Feedbacks from students allowed the author to make changes. Feedbacks were gathered in a questionnaire, anonymously. Two main sections were distinguished in the questionnaire. 7 questions were asked to be graded from 1 as completely disagree, to 5 as completely agree about the quality of information and evidence as well as 2 open questions to know what to improve and what student would remember the most.

On average, students spent 50min completing the self-learning material. The quality of information and evidence were graded as good. The main issue came from the amount of information. The author made changes by shortening parts while keeping relevancy. Questionnaire is found in appendix.

9 DISCUSS ION

The author thinks that writing a thesis is an overwhelming yet rewarding process. It was, for the author, a great journey into reading studies and searching for the best available piece of information. The overwhelming part was connected to the questions "where to start? Where to look?". When it comes to Achilles tendinopathy, the number of sources, studies and information is, nowadays, countless, and various. The author quickly found himself passionate by the topic and it became easier to continue the writing process. The rewarding part was to realize that every piece of information within the thesis come together and make sense as the work progress. It became then straightforward and an exciting challenge to carry. On a personal note, the authors realized that life event directly impacted the motivation and the writing. The process slowed down due to a difficult adaptation to practical placement. Great determination and support system, from thesis supervisor and personal social circle, enabled the author to write most of the theoretical part before the practical placement abroad. It gave the author time to review the writing and start creating the H5P learning material. Using the H5P platform was a new and enjoyable task due to its accessibility.

With his thesis topic, the author aimed to bring more information about Achilles tendinopathy in general as well as to increase awareness on the kinetic chain approach in the rehabilitation of distal lower leg injuries. The author focused quickly on gluteal muscles due to early readings leading to this hypothesis. The first challenge the author encountered, was facing the amount of information about Achilles Tendinopathy, the definition, the cause, treatment, and prevention. As the topic was not strictly about Achilles tendinopathy, it was crucial for the author to gather the latest effective information for the reader to have a general understanding of the injury. The author wanted to give practical information about the process of the injury and its assessment, due to future profession of the potential readers.

The second challenge for the author was to gather evidence on the connection between gluteal muscles and Achilles tendinopathy. To the current author's knowledge, the direct correlation between Achilles tendinopathy and dysfunction of gluteal muscles is neither available, nor fully studied, nor proven. At that point, the author questioned the relevance of his topic. Nevertheless, the author found out very interesting studies enlightening the connection between gluteal muscles and distal leg injuries, such as chronic ankle instability, patellofemoral syndrome, amongst other. The biomechanical research confirmed to the author the worth of this thesis as the author realized the impact of hip rehabilitation on foot.

The author is aware that his thesis is only a small piece of brick to the wall of information regarding this specific topic. Although, the author hopes that it brings new perspectives and vision on injury rehabilitation to physiotherapy students, the same way the process helped the author. The practical part of this thesis is, for the author, a means to this objective. Achilles tendinopathy being a common injury, students making a physiotherapy career in musculoskeletal and sport field are most likely to encounter it. The H5P document give physiotherapy students a deeper knowledge on this specific injury and its rehabilitation.

This process gave the author a better understanding of the kinetic chain and holistic approach to lower limb injury. The author hopes the reader will come to this realization.

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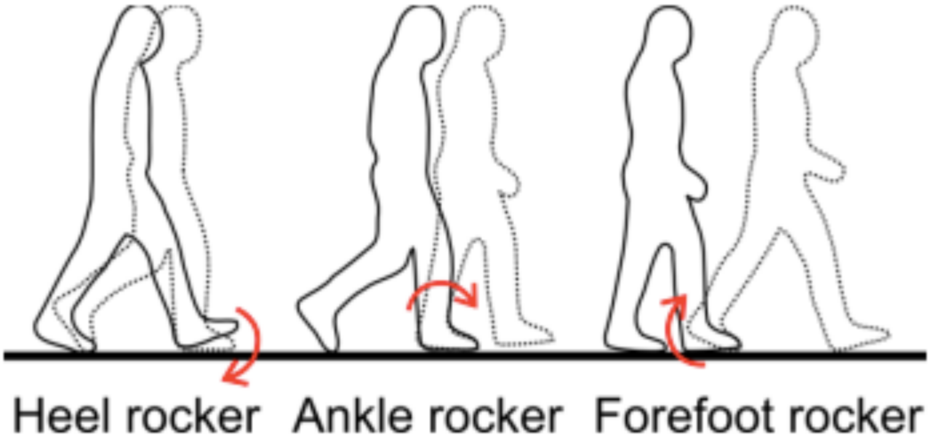
APPENDIX



To complete this material I spent about (time): *

Votre réponse

The material was clear and easy to follow *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	Completely agree

Questions make it easier to understand and follow *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	Completely agree

I broadened my knowledge about Achilles Tendinopathy and its rehabilitation *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	completely agree

I think the material was built in a proper order *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	Completely agree

The material brought me enough evidence-based information *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	Completely agree

The amount of information was right *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	Completely agree

I would recommend the material to other physiotherapy students *

	1	2	3	4	5	
Completely disagree	○	○	○	○	○	Completely agree

What information would you remember the most after completing this material ? *
(key words)

Votre réponse

In your opinion, what could be done to improve your learning from this material ? *
Length ? Information ? Evidence ? Questions ? ...

Votre réponse